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SPECULATIONS REGARDING THE GENESIS OF THE DIAMOND

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The recent admirable summary by Dr. Percy A. Wagner[1] of what is now definitely known regarding the geological conditions in which the diamond occurs in South Africa suggests certain speculative points of view, which, if found worthy of attention, may in turn suggest desirable lines of investigation in the field and the laboratory. These inquiries may perchance throw light on the intricate, fascinating question of the genesis of the diamond; or, even in a broader way, on the rôle of carbon in eruptive rocks, whether in the form of diamond or graphite, or as gas locked up in carbonates or certain silicates.

To the student of the occurrence of the diamond in countries other than South Africa, one of the most significant facts established by the prospecting of the African miners is that, aside from its well-known occurrence in pipes, the diamond-bearing eruptive material, kimberlite, occurs also in dikes, and that these usually have considerable longitudinal extension but only small width, except where expanded into pipes, and even these are frequently insignificant in relative dimensions. This slight prominence of the diamond-bearing bodies, coupled with the extreme susceptibility of the material to alterations which render its identification a matter of great difficulty, suggests at once that the failure to detect such dikes and pipes in districts in which the diamond is found only in sedimentary deposits, modern or ancient, is not a conclusive argument against their existence, nor is it clear evidence that the original matrix was notably different from the South African kimberlite. In countries like India and Brazil, in which the diamonds of the modern alluvial deposits have been definitely traced back to conglomerates of considerable geological age, the presence or absence of kimberlite dikes should be tested by prospecting operations, not so much, perhaps, in the areas occupied by the conglomerates themselves as in the neighboring ones occupied by formations known to have been in existence when the conglomerates were laid down, and which have escaped being covered up by them or by later strata. Until such prospecting is done on a sufficiently large and efficient scale the opinion, which a few years ago seemed justified, that a mode of occurrence essentially different from the African must be postulated for these countries, should be held in suspense.

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[1] *Die diamantführenden Gesteine Südafrikas*, Berlin, 1909.

The material filling the African pipes shows very pronounced fragmenting and apparently explosive action, which has shattered, and to some extent scattered, the eruptive rock characteristic of both the pipes and the dikes and has mixed it with a very considerable amount of various other rocks, either brought up with it from lower horizons or detached from the surrounding rock masses. Discussion is still going on as to whether the diamonds contained in these agglomeritic pipe-fillings are to be assigned to the eruptive rock proper or to some of the foreign rocks included in it, but the weight of evidence seems to be in favor of the first hypothesis. A very interesting view that was held for many years assigned the formation of the diamond to some kind of reaction *in situ*, between the two classes of rock that occur in the pipes, the necessary carbon being supplied by the carbonaceous rocks through which, in some places, the pipes cut. Subsequent developments have completely disproved this hypothesis, but the essential part of it—the formation of the diamond *in situ*—is still worthy of consideration *if another source of carbon can plausibly be brought into the question.*

So general is the association of the diamond with a fragmental state of the eruptive rock that enters into the composition of the pipes that the question naturally arises whether or not the diamond also occurs in such masses of this rock as have not been subjected to the fragmenting action. From the statements at hand it is clear that there is usually considerable difficulty in distinguishing between the massive and the fragmental forms of kimberlite. Apparently the distinction has only been made in a perfectly conclusive manner by the use of the microscope. The masses that can be thus examined are so small that such negative evidence as they may give has in itself little value. Specimens of diamonds inclosed in fragmental material are quite common, but thus far those found in which the rock is clearly non-fragmental seem to be exclusively of the type of the so-called "eclogite nodules," which are regarded by some as segregations in the kimberlite magma and by others as transported fragments of a pre-existing rock. In either case the experimental crushing, reported by Mr. Gardner Williams,[1] of 20 tons of these nodules from the Kimberley mine without finding a single diamond, tells strongly against any general hypothesis of genesis based on the sporadic occurrence of these nodules.

In the statements at hand relative to the occurrence of diamonds in the parts of dikes that are not expanded into pipes, the impression is given that the rock is non-fragmental; but the evidence on this point is not as clear as one could wish. As the case stands at present, and until unequivocal evidence to the contrary is presented, there is a reasonable presumption that a positive, perchance a genetic, relation exists between the diamond and the fragmental condition of the rock in which it occurs. This in turn may mean that the origin of the diamond can perhaps be assigned to reactions between the original rock, or rocks, of the filling and other elements whose introduction was made possible by the fragmenting of the mass, and which accompanied, or followed, the explosive action, if, perchance, they did not constitute the actual agency that produced it.

According to ideas generally received among geologists, the explosive action, as such, is but the culmination of previous thermal processes in the sudden production of gases, principally water vapor. The thermal processes may be protracted and varied in action and may occur repeatedly and extend into late phases of the eruptive period and to stages subsequent to it. One of the most important effects of the protracted action would be to saturate the fractured mass of rock with gases and with liquids resulting from their condensation. Various observers have expressed the opinion that this saturation under the conditions implied reached the point of establishing a marked degree of mobility in the mass, converting it into a veritable rock brew. Be this as it may, such a saturation, whatever its degree may have been, would establish conditions in which a certain amount of hydration (serpentinization) of the eruptive rock, composed largely of olivine, would almost inevitably result.

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[1] *Trans. Am. Inst. Min. Engineers*, 1904.

We thus have in the formative stages of the pipe-fillings (or at least in early stages of their history) a sufficient agency for the hydration of their eruptive portions. Such a change has been observed down to such extraordinary depths that the usual explanation of atmospheric weathering seems utterly incredible.[1] The hydration, which to a greater or less degree seems to be characteristic of all known occurrences of undoubted kimberlite, whether appearing in pipes or dikes, is accompanied by the formation of a certain amount of calcite, which involves the introduction, in some stage of the history of the rock, of carbon in a condition to form the carbonic acid locked up in the mineral. This introduction may also be most plausibly assigned to the stage of thermal agitation, of which the fragmenting and explosive actions were the climax. The analysis cited in the preceding note, representing the least-altered kimberlite thus far examined, gives 2.54 per cent of carbonic acid, corresponding to about 5,000 grams of pure carbon to the unit of volume (load=0.453 cubic meters) used by the African miners in measuring their material. This amount of carbon, if present in the form of diamond, would give about 25,000 carats, whereas the usual yield of the De Beers load is under 1 carat (1/5 gram).

There are thus strong a priori reasons for attributing to deep-seated causes long since extinct a great part of the hydration and carbonation which the eruptive rock, originally free from water carbon, has suffered. If such was the case, it becomes important to distinguish the deep-seated actions from those of the atmosphere, which, acting from above downward, have long been producing similar results. These superficial results would be superimposed on the pre-existing ones, if such existed, down to a certain depth. No question can be raised regarding the correctness of the view, very generally received, that atmospheric weathering has transformed the "hard blue" ground into "soft blue," and this in turn into "yellow" ground. If, as here suggested, there had been a previous period in which serpentine and calcite were formed, evidence for or against it should be found in the transition zone between the hard and the soft blue ground. So far as can be gathered from the literature at hand careful search has never been made for such evidence. This seems thus to be one of the crucial points in the study of the genesis of the diamond that is yet to be investigated.

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[1] Dr. Wagner gives an analysis of a specimen of kimberlite collected in the deepest part (2,040 feet from the surface) of the De Beers mine, which had 6.81 per cent of combined water. This, as he expressly states, represents the best-preserved material to be found in the Kimberley group of mines, although in the neighboring Kimberley mine the pipe has been opened up nearly 1,000 feet farther down, or fully 3,000 feet from the surface. From this it may legitimately be inferred that there is little likelihood of finding unhydrated kimberlite in the known South African diamond mines.

On the assumption that future investigation may establish the deep-seated origin of the alteration of the diamond matrix, a basis is found for submitting to discussion the elements of a new hypothesis regarding the genesis of the diamond. A pipe filled with rock fragments saturated with hot (possibly superheated) gases, and probably also liquids, would constitute an enormous crucible, in which reactions not as yet detected in our laboratories might take place. In this crucible carbon would certainly be present in the form of carbonic acid and probably in other gaseous forms as well. Thus the material and some of the physical conditions for unusual carbon segregation were present, and we are not yet, apparently, in a position to say that a segregation of a minute portion of the carbon into a solid form is a chemical impossibility. It seems to be well established that in certain industrial and experimental processes carbon does separate in the solid form of graphite from carbonaceous gases, and Weinschenk has presented strong evidence in favor of the introduction in a gaseous form of the carbon of the graphite deposits of Bohemia and Bavaria.

From a geological point of view the rôle of carbon in eruptive rocks and in eruptive phenomena generally is as important as it is obscure. It thus presents an attractive subject for experimental researches, such as are contemplated in the program of the Geophysical Laboratory at Washington, which is so admirably equipped both in material and personnel for such investigations. The inquiries in this line thus far reported by various experimenters, while extremely interesting and important in themselves, are unsatisfactory, in so far as they postulate conditions that are with difficulty conceivable in nature.